§12. Transition of Fluctuation Characteristics Observed by a Heavy Ion Beam Probe in the JIPP T-IIU Tokamak

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Measurement of the plasma potential fluctuations in tokamak plasmas by HIBP is rather difficult compared to the density fluctuations, because the ratio of the expected potential fluctuations to the beam energy is very small compared to the observed density turbulence of $\tilde{n}_e/n_e = 0.01$-0.1. Accordingly the measurement of the potential turbulence has low signal to noise ratio (SNR) and the measurement of the potential turbulence tends to be influenced by the circuit noise of the detector amplifier and by the radiation from the plasmas in the core region. Near the boundary we performed the measurement of potential turbulence with a high SNR. The toroidal field is 3 Tesla. The scanning of the primary beam across the plasma cross-section is performed by the poloidal and toroidal sweepers at the entrance to the tokamak. The energy analyzer is a parallel-plate electrostatic analyzer with the injection angle of 30 degrees and a shaped high-voltage plate for uniform electric field across the plates. In order to detect the k-spectrum accurately compared with 2-point measurement, we installed 7 input slits and 7 sets of detectors (stainless-steel upper and lower plates for potential measurement or left and right plates for magnetic measurement, connected to low noise amplifiers). The distance between the slits is 1 cm and the slit opening is 3 mm. Potential is measured through the $ND=(i_u-i_d)/(i_u+i_d)$, where i_u, i_d are beam currents of the upper and lower detector plates respectively. Figure 1 show the position and shape of 7 sample volumes (SV) at each poloidal steps, the correlation coefficient functions (CCF) of the signal of the first SV and signals of other SV, $\rho_{1,j}(t)$, j=1,2,3,4,6 , for the sum of the detector current, ND at 300 keV . It also shows CCF of the total of the sum of the 1st and 2nd detector and difference of ND, <(sum(1) + sum(2)) (ND(1)-ND(2))>, correlation of density and local electric field. The correlation coefficient function $r_{i,j}(t)$ of $s_i(t)$ and $s_j(t)$ is written by $\rho_{i,j}(\tau) = \dfrac{C_{i,j}(\tau)}{\sqrt{C_{i,i}(0)}\sqrt{C_{j,j}(0)}}$, where $C_{i,j}(t)$, the cross correlation function, is given by

$$C_{i,j}(\tau) = \int_{-\infty}^{\infty} \tilde{s}_i(t)\tilde{s}_j(t+\tau)dt.,\text{with}$$

$\tilde{s}_i(t) = s_i(t) - \overline{s_i(t)}$. The integration time in this case is 3 ms instead of from infinity to infinity. The beam radius in the plasma is 3 mm.

As for the micro-scale potential fluctuations we got a statistically stable value for the correlation between density and local electric field, proportional to the turbulence-driven particle flux, near the plasma boundary. The calculated particle confinement time based on this correlation, in the case of the step d of Fig. 3, gives 1.5 ms while the energy confinement time is about 5 ms. Accordingly our results may be similar to those of turbulence-driven flux measurement in TEXT HIBP[1].

Reference

1) J. C. Forster et al., Trans. on Plasma Science, **22** (1994) 359.

Fig. 1. Positions of the sample volumes and correlation coefficient functions of the sum, ND, and <(sum(1) + sum(2)) (ND(1)-ND(2)> proportional to correlation of density and local electric field at 300 keV.